EXACT ENGLISH LANGUAGE TRANSLATION OF THE PCT APPLICATION AS ORIGINALLY FILED WITH ABSTRACT

The present invention is a method and a device used to establish and/or maintain defined conditions of temperature and humidity in a building.

It is used notably, but not exclusively, for cooling dwellings, sports halls, industrial buildings and buildings for livestock during periods of high temperatures.

To cool ambient air, air-conditioners are often used which are an effective solution for reducing the temperature of the buildings in which they are located. However they have the disadvantage of being relatively expensive, have high running costs, high energy consumption and their heat and noxious gas emissions means they are not ecological, further they have a drying effect on the ambient air.

In order to cool ambient air, fans are also used which move the air thus alleviating the sensation of heat, but they do not, in reality, reduce the air temperature and have no effect on the degree of humidity in the room.

The invention is therefore designed particularly to remedy these disadvantages with a method as well as a device implementing the said method which is based, in part, on endothermic reactions, and which are used to establish and maintain defined conditions of temperature and humidity in a building.

To achieve this, the method establishes and/or maintains defined conditions of temperature and humidity in a building according to the following steps:

- the filling with water of a supply reservoir connected to an evaporator / exchanger;
- the passage of the water contained in the supply reservoir through the tubes or hollowed-out elements of an evaporator / exchanger;
- the exudation of a part of the water circulating in the evaporator / exchanger on the external walls of the said tubes or said hollowed-out elements, the exudation being possible due to the porosity of the material which constitutes the tubes or hollowed-out elements;
- the creation of a thin film of water on the external walls of the said tubes or hollowed-out elements;
- the subsequent evaporation of this film of water provoking, by endothermic reaction, a cooling of the water circulating in the tubes or hollowed-out elements;
- the generation, by a means of ventilation, of a flow of air which is to be cooled;
- the spraying of the refrigerated water in the said airflow, using a means of spraying, in order to create a humidified and cooled airflow.

According to a variant of the execution of the invention, the said method comprises the following supplementary steps:

- the collection of the refrigerated water, after its passage in the tubes or the hollowed-out elements, in a collection reservoir;
- the aspiration of the refrigerated water contained in the collection reservoir, using a means of aspiration, in order to direct it towards the said means of spraying.

According to another variant of the execution of the invention, the said

method comprises the following supplementary steps:

- the collection of the refrigerated water, after its passage in the tubes or the hollowed-out elements, in a collection reservoir;
- the transfer of the refrigerated water contained in the collection reservoir to the supply reservoir, using a means of aspiration, the water moving through a tube linking the supply reservoir to the collection reservoir;
- the injection of the cooled water contained in the supply reservoir into the means of spraying.

Advantageously, the refrigerated water may be directly sprayed, using the said means of spraying, on the structure of the evaporator / exchanger and the refrigeration of the water will be obtained by the combination of three effects:

- the evaporation of the film of water provoking, by endothermic reaction, a cooling of the water circulating in the tubes or hollowed-out elements;
- the spraying of the refrigerated water on the structure of the evaporator / exchanger, using a means of spraying, in order to optimise the cooling of the said structure;
- the generation, by a means of ventilation, of a flow of air, this flow of air assists in accelerating the evaporation of the said film of water thus optimising the endothermic reaction and so the cooling of the water circulating in the tubes or hollowed-out elements.

Advantageously, so that the endothermic reaction may take place throughout a complete cycle of the implementation of the steps of the said procedure, the spraying of the refrigerated water on the structure of the evaporator / exchanger may be effected in an intermittent manner.

Advantageously, the refrigerated water contained in the collection reservoir may also be used, for example, to water livestock.

The method is implemented with a device which has:

- a supply reservoir connected to an evaporator / exchanger;
- an evaporator / exchanger comprising tubes or hollowed-out elements, made of a porous material, through which the water coming from the supply reservoir circulates;
- a means of pulverisation;
- a means used to transmit the refrigerated water contained in a collection reservoir or in a supply reservoir to the means of spraying;
- a means of ventilation generating a flow of air directed toward the means of spraying in order to produce a humidified and cooled airflow;
- a collection reservoir collecting the refrigerated water coming from the evaporator / exchanger.

According to an execution variant of the invention, the said tubes or the hollowed-out elements are made of a heat-conducting material and are coated with a material which absorbs the water projected onto the said tubes or the hollowed-out elements. Consequently, the evaporation of the water retained by this absorbent material will cause, by endothermic reaction, a cooling of the water circulating in the tubes or the hollowed-out elements.

Advantageously, the devices of the said type may be modular, and they may then be superposed or juxtaposed to form an assembly which is adjustable according to the volume of the building in question.

Advantageously, the device may be driven remotely by means of a controlling device which notably allows the user to actuate the device and control the intensity and length of the duty cycle of the device. This control device may comprise indicators for temperature, humidity, rate of airflow, etc.

The execution modes of the invention are given in descriptions below, as indicative examples of use, with reference to appendix drawings, in which:

Figure 1 is an overall cross-section of the device according to the invention.

Figure 2 is an overall perspective view of a mobile device which is intended, preferably, for use in small buildings.

Figure 3 is a perspective view of the evaporator / exchanger of the device according to the invention.

Figure 4 is an overall cross-section of a fixed system comprising several superposed devices according to the invention, this system being intended, preferably, for use in medium sized or large buildings.

Figure 5 is an overall perspective view of the device as a module, in accordance with an execution variant of the invention.

Figure 6 is a perspective view of a livestock building with a system comprising several of the devices according to the invention.

Figure 7 is a cross-section of a connecting plate fitted with tubes which is part of the system shown in figure 4.

The method according to the invention comprises the following steps:

- the filling with water of a supply reservoir 1 connected to an evaporator / exchanger 2;
- the passage of the water contained in the supply reservoir 1 through the tubes 3 or hollowed-out elements 3 of an evaporator / exchanger

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- the exudation of a part of the water circulating in the evaporator / exchanger 2 on the external walls of the said tubes 3 or said hollowed-out elements 3, the exudation being possible due to the porosity of the material which constitutes the tubes 3 or hollowed-out elements 3;
- the creation of a thin film of water on the external walls of the said tubes 3 or hollowed-out elements 3;
- the subsequent evaporation of this film of water provoking, by endothermic reaction, a cooling of the water circulating in the tubes 3 or hollowed-out elements 3;
- the generation, by a means of ventilation 7 of a flow of air which is to be cooled;
- the spraying of the refrigerated water in the said airflow, using a means of spraying 6, in order to create a humidified and cooled airflow.

In the example represented in figure 1, the device according to the invention 8 comprises:

- a supply reservoir 1 connected to an evaporator / exchanger 2;
- an evaporator / exchanger 2 comprising tubes 3 or hollowed-out elements 3, made of a porous material, through which the water coming from the supply reservoir 1 circulates;
- a means of spraying 6 placed behind the said evaporator / exchanger 2 which sprays refrigerated water, coming from a collection reservoir 4, on the structure of the evaporator / exchanger 2;
- a means of aspiration 5 used to transmit the refrigerated water contained in the collection reservoir 4 toward the means of spraying 6;
- a means of ventilation 7 placed behind the means of spraying 6 which generates a flow of air directed toward the means of spraying

6 in order to produce, on contact with the evaporator / exchanger 2, a humidified and cooled airflow;

- a collection reservoir 4 arranged beneath the evaporator / exchanger 2 collecting the refrigerated water coming from the evaporator / exchanger 2.

So, the device 8 shown in figure 1 implements the execution variant of the invention according to which the said method comprises the following supplementary steps:

- the collection of the refrigerated water, after its passage in the tubes 3 or the hollowed-out elements 3, in the collection reservoir 4;
- the aspiration of the refrigerated water contained in the collection reservoir 4, using a means of aspiration 5, in order to direct it towards the said means of spraying 6.

Further, the refrigerated water being directly sprayed on the structure of the evaporator / exchanger 2 with the means of spraying 6, this spraying may be effected intermittently using the means of spraying 6 so that the endothermic reaction may take place throughout a complete cycle of the implementation of the steps of the said procedure.

The supply reservoir 1 which will be advantageously insulated, has an orifice 9 by which the reservoir 1 is filled with water. This orifice 9 which may be situated on the upper face of the said reservoir 1 may be closed by a small flap 10 or by a screw stopper 10 and will be sufficiently wide for the introduction of ice cubes in the supply reservoir 1 in order to have refrigerated water available more quickly.

Advantageously, the supply reservoir 1 has a greater capacity than that of the collection reservoir 4 further, as shown in figure 4, it may be directly linked to the mains water supply by an appropriate pipe 11 which may be a rigid tube or

a flexible tube reinforced with a metal braid.

The tubes 3 or the hollowed-out elements 3 of the evaporator / exchanger 2 are made of a porous material which is preferably an ordinary ceramic with open porosity such as terracotta or earthenware which allows the sweating of the water thus creating a thin film of water on their external walls, the subsequent evaporation of this film provoking, by endothermic reaction and in accordance with the principle of the functioning of "alcarazas", a cooling of the water circulating in the tubes or the hollowed-out elements 3. In order to optimise the exudation method, the tubes 3 or the hollowed-out elements 3 will preferably be arranged vertically.

According to an execution variant of the invention, the said tubes 3 or the hollowed-out elements 3 are made of a heat-conducting material and are coated with a material which absorbs the water projected onto the said tubes 3 or the hollowed-out elements 3. Consequently, the evaporation of the water retained by this absorbent material will cause, by endothermic reaction, a cooling of the water circulating in the tubes 3 or the hollowed-out elements 3. In this case, the tubes 3 or the hollowed-out elements 3 may be arranged horizontally.

The number of tubes 3 or hollowed-out elements 3, their interior diameter or width, which will preferably be reduced in order to optimise the exudation method, their height, their wall thickness, which will preferably be of medium dimension so that the tubes 3 or the hollowed-out elements 3 may be manufactured using existing mechanised methodes of the ceramics industry, are calculated using the following two parameters:

- the external surface of exchange of the tubes 3 or the hollowed-out elements 3 from which the volume of air which may be cooled can be calculated;
- the internal volume of the tubes 3 or the hollowed-out elements 3

from which the capacity of water which may be refrigerated can be calculated.

Further, in order to increase the surface of thermal exchange of the tubes 3 or the hollowed-out elements 3, these may advantageously comprise several channels for a better circulation of water. The manufacture of these tubes 3 or these hollowed-out elements 3 comprising several channels will be effected, advantageously, with an increase in their width while taking care not to significantly increase the exterior diameter of the tubes 3 or the thickness of the hollowed-out elements 3 so that the circulation of the forced air remains efficient.

Advantageously, the tubes 3 or the hollowed-out elements 3 may be arranged in front of and also behind the means of ventilation 7 so that they are in the aspiration flow and in the backdraught of the means of ventilation 7.

According to an execution variant of the invention (not shown), the tubes 3 or the hollowed-out elements 3 may take the form of a coil with fans to facilitate the passage of the forced air and to obtain a greater surface of thermal exchange.

The evaporator / exchanger 2 is linked to the supply reservoir 1 and the collection reservoir 4 by an upper distribution chamber 12 and by a lower collection chamber 12 which may be in plastic, rubber or ceramic. So, assuming that the tubes 3 or the hollowed-out elements 3 are arranged vertically, the evaporator / exchanger 2 is linked respectively to the supply reservoir 1 and the collection reservoir 4 by this distribution chamber 12 and this collection chamber 12, each comprising supply tubes (not shown) which cap respectively the upper and lower parts of each tube 3 or hollowed-out element 3, this distribution chamber 12 and this collection chamber 12 being respectively linked to the supply reservoir 1 and to the collection reservoir 4

by a tube 13.

The means of aspiration 5 may be a variable-speed electric pump including a selector of pre-defined speeds or a continuous speed variator, the speed being determined either manually or automatically.

The means of ventilation 7 which generates an airflow directed toward the means of spraying 6 may run at a variable speed and so comprise a selector of pre-defined speeds or a continuous speed variator, the speed being determined either manually or automatically. It may be a vertical blade fan or a turbine with horizontal vanes.

A humidity probe (not shown) as well as a thermostatic probe (not shown) will control the means of aspiration 5 and the means of ventilation 7 respectively in order to be able to automatically determine the quantity of water vaporised by the means of spraying 6 and the volume of air generated by the means of ventilation 7. Advantageously, the humidity probe as well as the thermostatic probe may be contained together in an external unit (not shown), placed in the building to be cooled; this unit may be linked to the device 8 by means of a wireless transmission allowing it to be placed anywhere in the building.

Advantageously, the said unit may also comprise controls (an on/off switch, speed selectors, etc.) as well as indicators (alarm, on/off, etc.) so allowing the device according to the invention 8 to be controlled remotely.

In order to direct the airflow generated by the means of ventilation 7 toward the means of spraying 6 as well as toward the structure of the evaporator / exchanger 2, the median zone of the device 8 in which are arranged the means of spraying 6, the evaporator 2 and the means of ventilation 7 may contain a housing having approximately the shape of a truncated pyramid, axis oriented horizontally, with the large base and the small base turned respectively toward

the forward and rear face of the device 8.

The humidified and cooled flow of air generated by the means of ventilation 7 is propelled out of the device according to the invention 8 by passing through an exit grill 18 comprised in the forward face of the said device 8.

The device according to the invention 8 comprises an air intake grill 15 comprised in the rear face of the device 8, and this grill may comprise a filter (not shown) to prevent the aspiration of dust which may prejudice the correct working of the apparatus. This air intake grill 15 may also have flaps or shutters which may be closed partially or completely.

The collection reservoir 4 which will be advantageously insulated comprises a draining plug (not shown) in the lower face of the device according to the invention 8 to allow the complete evacuation of the water contained in the collection reservoir 4 when the device 8 is not in use.

To ensure the seating of the device 8, a ballast may be fixed on the lower face of the device 8.

Advantageously, in order to check the level of water in the supply reservoir 1, a transparent window may be comprised in the front face of the device according to the invention 8.

The supply reservoir 1 may have a float 16 protected from the ice cubes by a grill (not shown) or by a perforated sheet envelope (not shown), this float 16 controlling an alarm which is sonic (for example, repetitive beeps) and / or visual (for example, a blinking red light) to indicate that the reservoir 1 must be filled, and the device 8 may be turned off if this refilling doesn't take place within a predetermined lapse of time.

The controls (on/off switch, speed selectors, etc.) as well as the indicators (alarm, on/off, etc.) may be placed together on a panel 17 on the front or upper face of the device 8.

In the case where the supply reservoir 1 is directly linked to the mains water supply, the float 16 may automatically control the opening of an inlet valve as soon as the level of water reaches a minimum and the closure of the inlet valve as soon as the water level reaches a maximum.

Advantageously, the device according to the invention 8 may be mounted on castors 19.

A duty cycle of this device, such as the one shown in figure 1, is then as follows:

- the supply reservoir 1 is filled with water, preferably slightly mineralised or filtered to avoid the scaling-up of the tubes 3 or the hollowed-out elements 3;
- the device 8 is turned on, which would be verified by means of the on/off indicator, placed on the panel 17;
- the water coming from the supply reservoir 1 circulates in the tubes 3 or the hollowed-out elements 3 of the evaporator / exchanger 2, part of this water being exuded onto the external walls of the said tubes 3 or the said hollowed-out elements 3;
- a thin film of water is created on the external walls of the said tubes 3 or said hollowed-out elements 3;
- the film of water evaporates provoking, by endothermic reaction, a cooling of the water circulating in the tubes 3 or hollowed-out elements 3;
- the means of ventilation 7 is started up and generates a flow of air directed toward the means of spraying 6 and the structure of the evaporator / exchanger 2;

- the means of aspiration 5 is started up and directs the refrigerated water contained in the collection reservoir 4 toward the means of spraying 6;
- the means of spraying 6 intermittently sprays onto the structure of the evaporator / exchanger 2 a cloud of refrigerated water, the frequency of spraying being controlled by a humidity probe located close to the external air intake;
- the flow of air thus humidified and cooled is propelled toward the exterior of the device 8 through the exit grill 18.

The duty cycle of the device according to the invention 8 continues as long as the water present in the supply reservoir 1 has not fallen to the minimum.

According to a variant of the execution of the invention, the said method comprises the following supplementary steps:

- the collection of the refrigerated water, after its passage in the tubes 3 or the hollowed-out elements 3, in a collection reservoir 4;
- the transfer of the refrigerated water contained in the collection reservoir 4 to the supply reservoir 1, using a means of aspiration 35, the water moving through a tube 34 linking the supply reservoir 1 to the collection reservoir 4, the refrigerated water contained in the collection reservoir 4 may also be directed toward cold air diffusion elements which are distributed around the building to be cooled;
- the injection of the cooled water contained in the supply reservoir 1 into means of spraying.

So, as it is shown in figure 4, the device 8 may, for the implementation of the method according to this execution variant of the invention, be modular allowing them to be superposed and juxtaposed so as to build a fixed assembly, according to the volume of the building in question.

For the superposition of the modular devices 8, the tubes 3 or hollowed-out elements 3 of these modular devices 8 are mounted in parallel on a chassis 20 of four plates which may be made of stainless steel or built from galvanised pressed steel. Each extremity of the tubes 3 or hollowed-out elements 3 is capped with a protruding semi-rigid connecting tube 60 which may be in plastic or rubber, and modelled so that it can be fitted to one of the tubes 21 which are part of connecting plates 22, these plates being placed respectively above and below the upper and lower plate of the frame 20, the retention of the said connecting tube 60 in the said tubes 21 of the connecting plates 22 being effected with clips in metal or plastic 23.

If the hollowed-out elements 3 are 10 centimetres or more in width, they will be capped with a ceramic supply or reception funnel.

The tubes 21 of the connecting plates 22 arranged on the upper plates of the chassises 20 constitute a female cavity whereas the tubes 21 of the connecting plates 22 arranged on the lower plates of the chassises 20 constitute a male cavity. In this way, the superposition of the devices according to the invention 8 is made possible as the connecting plates 22 ensure the watertightness of the assembly which may be optimised by placing toric joints 29 on the said tubes 21 of the connecting plates.

The connecting plates 22 placed at the top and the bottom of the assembly, constituted by juxtaposing devices according to the invention 8, are linked to auxiliary tanks 25, the upper auxiliary tank 25 and the lower auxiliary tank 25 comprising respectively male tubes (not shown) and female tubes 26 which can work together with the tubes 21 of the connecting plates 22 so that the said connecting plates 22 are linked to the auxiliary tanks 25. The upper and lower auxiliary tanks 25 are respectively linked to a supply reservoir 1 and to a collection reservoir 4 by a linking tube 27.

Advantageously, so that the device according to the invention 8 may be juxtaposed, the lateral plates/flanges/guides of the chassis 20 may comprise means of connection such as male or female cavities.

The assembly constituted by the juxtaposition of devices according to the invention 8 comprises a supply reservoir 1 which may be linked to the mains water supply by an appropriate pipe 11 which may be a rigid tube or a flexible tube reinforced by a metal braid.

The filling of the supply reservoir 1 may be controlled by a float valve (not shown) in the said supply reservoir 1 and adjusted to a height so that an intermediate level may be ensured in order that a sufficient volume is reserved for the refrigerated water provided by the collection reservoir 4 by a means of aspiration 35.

The upper part of the supply reservoir 1 will have an air-hole so that the water flows freely.

The supply reservoir 1 is linked to a collection reservoir 4 by a tube 34 including a means of aspiration 35 so that the refrigerated water contained in the collection reservoir 4 may pass to the supply reservoir 1. The collection reservoir 4 comprises a solenoid valve 30 which, when it is open, allows the water contained in this reservoir 4 to pass to the said tube 34. This solenoid valve 30 is controlled by a thermostat 31 linked to two probes 32, 33, one 32 in the supply reservoir 1 and the other 33 in the collection reservoir 4. With this set-up, when the temperature difference, registered by the thermostat 31, reaches a value which has been pre-set by the user (for example, 5 degrees), the solenoid valve 30 opens and the means of aspiration 35 is started up so that the supply reservoir 1 may be provided with refrigerated water.

The supply reservoir 1 comprises a pressure switch 36 used to turn off the means of aspiration 35 as well as to close the solenoid valve 30 when the volume of refrigerated water transferred into the supply reservoir 1 has completely filled the said reservoir 1.

Advantageously, the refrigerated water contained in the collection reservoir 4 may also be directed toward cold air diffusion elements which are distributed around the building to be cooled; these elements may, for example, be car radiators. So, the means of aspiration 35 transfers the refrigerated water via a branch of the tube 34 in order to supply these diffusion elements.

Advantageously, this cycle of filling the supply reservoir with refrigerated water coming from the collection reservoir 4 is restarted periodically.

The collection reservoir 4 which will be Advantageously insulated comprises a drainage plug (not shown) as part of the lower face of the device according to the invention 8 to allow the complete evacuation of the water contained in the collection reservoir 4 when the device 8 is not in use.

Each modular device 8 comprises a means of ventilation of the said type placed either in front of the tubes 3 or the hollowed-out elements 3 comprised in each modular device 8 (these situated therefore in the aspirated air flow), or behind the said tubes 3 or hollowed-out elements 3 (these situated therefore in the propelled air flow). These means of ventilation may consist of a fan or a vertical-blade turbine, and may run at a variable speed and comprise a selector of pre-defined speeds or a continuous speed variator, the speed being determined either manually or automatically. Thermostatic probes distributed in the building to be cooled may be used to drive the variable speed of these means of ventilation.

Advantageously, one or more modular devices 8 may be placed

simultaneously in front of the said means of ventilation and one or more modular devices 8 behind the said means of ventilation so that the exchange surfaces and the volumes of refrigerated water may be increased, according to the performance required which depends on the volume of the buildings in question, the regional climatic conditions, etc.

A means of spraying possibly consisting of a crown of atomising nozzles is placed in front of the means of ventilation, this means of spraying being supplied with refrigerated water by the supply reservoir 1 which comprises a solenoid valve controlled by a pressure switch 38. So, when the supply reservoir 1 is full the opening of this solenoid valve is actuated by the pressure switch 38, whereas when the level of water contained in the supply reservoir 1 returns to the said intermediate level, the solenoid valve is closed.

Advantageously, this modular device 8 may be remotely controlled with a control panel (not shown) which may comprise at least a humidity probe and/or at least a thermostatic probe and/or controls (an on/off switch, speed selectors, etc.) and/or indicators (alarm, on/off, etc.).

A duty cycle of this device 8, such as the one shown on figure 4, is then as follows:

- the supply reservoir 1 is filled with water from the mains water supply;
- the device 8 is turned on;
- water from the supply reservoir 1 after having passed through the upper auxiliary tank 25 passes through the tubes 3 or the hollowed-out elements 3 of the evaporator / exchanger 2, a part of the water is the object of an exudation on the external walls of the said tubes 3 or said hollowed-out elements 3;
- a thin film of water is created on the external walls of the said tubes 3 or hollowed-out elements 3;

- the film of water evaporates provoking, by endothermic reaction, a cooling of the water circulating in the tubes 3 or hollowed-out elements 3;
- water thus refrigerated is collected in the collection reservoir 4 after having passed through the lower auxiliary tank 25;
- if the difference in temperature registered by the thermostat 31 reaches a predetermined value, the solenoid valve 30 is opened and the means of aspiration 35 is started up;
- the passage of refrigerated water, coming from the collection reservoir 4, in the tube 34 and its progression toward the supply reservoir 1 and/or toward the cold air diffusion elements which are distributed around the building to be cooled;
- the stopping of the means of aspiration 35 and the closing of the solenoid valve 30 when the volume of refrigerated water transferred into the supply reservoir 1 has completely filled the said reservoir 1;
- the starting-up of the means of ventilation generating a flow of air which is propelled toward the means of spraying;
- the opening of the solenoid valve controlled by the pressure switch 38 when the supply reservoir 1 is full;
- the injection of the cooled air contained in the supply reservoir into the means of spraying, this being controlled by a humidity probe;
- the propulsion of the airflow, thus humidified and cooled, toward the exterior of the device 8.